DISCRETE X-RAY SOURCE POPULATIONS AND STAR FORMATION HISTORY IN NEARBY GALAXIES

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SECOND YEAR REPORT

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Discrete X-ray source populations and star-formation history in nearby galaxies

1 Project description and progress report

This program aims in understanding the connection between the discrete X-ray source populations observed in nearby galaxies and the history of star-formation in these galaxies. The ultimate goal is to use this knowledge in order to constrain X-ray binary evolution channels. For this reason although the program is primarily observational it has a significant modeling component.

During the second year of this study we focused on detailed studies of the Antennae galaxies and the Small Magelanic Cloud (SMC). We also performed the initial analysis of the 5 galaxies forming a starburst-age sequence. In more detail :

- **SMC**

A paper presenting the X-ray properties of the brightest X-ray sources detected in our *Chandra* survey of the SMC is going to be submitted to ApJ in the beginning of 2005 (Taylor *et al.*).

We have finished the identification with early type stars, of the X-ray sources detected in our survey of the SMC. We find in total counterparts for 89 of the 120 sources, 44 of which are new identifications. These results will be presented in a paper which we plan to submit in the beginning of 2005 (Antoniou *et al.*). We are also using these identifications in order to present a preliminary luminosity function of the High Mass X-ray binaries in the SMC. In order to extend these identifications to fainter, more evolved stars (and also identify sources not associated with the SMC) we have successfully applied and obtained high resolution, deep optical images of the *Chandra* fields, using the Magellan-Baade 6.5m telescope (Las Campanas observatory, Chile). In order to classify the brightest counterparts, we have also obtained optical spectra using the multi-fiber 2dF spectrograph at the AAT (Siding Springs Observatory, Australia). We are planning of analyzing the imaging and spectroscopic data in the first half of 2005. This will allow us to apply for deeper spectroscopic observations in the second half of 2005.

In order to extend the X-ray study to regions with stellar populations of different ages, we have successfully applied for XMM-Newton observations of 6 additional fields (3 fields were awarded as priority B targets and 3 fields were awarded as priority C targets). These new data will complement the *Chandra* observations of the central, youngest regions of the SMC, by extending our census to older stellar populations.

- **The Antennae**

In the case of the Antennae, we have finished the photometric analysis of the Chandra monitoring observations. The source catalogue together with the photometric, colour and

variability properties of the sources are presented in a paper submitted in the ApJ Supplement (Zezas et al). Another paper dealing with the properties of the diffuse emission of the Antennae was also submitted to the ApJ (Baldi *et al.*).

We have also analyzed the luminosity functions of the sources detected in the 7 observations, and we found that the variability of the individual sources does not affect the overall shape of their luminosity function. In the next year we are planning to submit three papers dealing with the multiwavelength counterparts of the X-ray sources, the luminosity functions and the spectral variability of the X-ray sources respectively.

- **Sample of starburst galaxies**

We obtained the *Chandra* data for the three star-forming galaxies (NGC 1569, NGC 4214 and NGC 51) which are part of a starburst-age sequence. We performed the initial analysis of these new data as well as any archival *Chandra* data for these galaxies and the one remaining objects from the starburst sequence (NGC 5253). These results indicate that the X-ray luminosity functions (XLF) of the discrete sources in these galaxies may not have the same shape as is widely suggested. However, any solid conclusions are hampered by the small number of detected sources. For this reason during the second year of this study, we will try to extend the sample in order to include more objects in each evolutionary stage. Moreover, in the case of NGC 4214 where we have deep multi-epoch observations we confirm the non dependence of the X-ray luminosity function on X-ray source variability.

- **Theoretical modeling**

In the theoretical front, we performed several tests of the Star-Track X-ray binary population synthesis code which will be used for the modeling of the X-ray binary populations (led by co-I V. Kalogera and C. Belczynski). We have initiated a large parameter study to investigate the effect of different star-formation and stellar evolution parameters in the modeled populations.

2 Presentations

Results from work funded under this LTSA program have been presented in the following conferences :

- Zezas, A., 2004. **X-ray binaries in nearby galaxies: the link between binary populations and galactic properties** (review talk), 204th AAS meeting (Denver, CO)

- Zezas, A. *et al.* , 2004, **Chandra monitoring observations of the Antennae and M 82 galaxies**, "Galaxies viewed with *Chandra* , workshop" (Cambridge, MA)

- Zezas, A. *et al.* , 2004, **Chandra monitoring observations of the Antennae and M 82 galaxies: the X-ray source populations and the shape of their X-ray luminosity functions**, COSPAR Assembly, session on "High-energy radiation from black-holes: from supermasssive black-holes to Galactic solar mass black-holes" (Paris, France)

- Zezas, A. 2004, **X-ray binary populations in star-forming galaxies**, (invited talk) COSPAR Colloquium, "Spectra and timing of compact X-ray binaries" (Mumbai, India)
- Zezas, A. *et al.* , 2004, **A *Chandra* survey of the bar region of the SMC** (poster), "Galaxies viewed with *Chandra* , workshop" (Cambridge, MA)
- Zezas, A. *et al.* , 2004, ***Chandra* observations of nearby mergers** (poster), "The environments of galaxies" (Chania, Greece)
- Zezas, A. *et al.* , 2004, **Evidence for past mergers in elliptical galaxies with very weak fine structure: *Chandra* observations of NGC 4261 and NGC 4697** (poster), "The environments of galaxies" (Chania, Greece)
- Antoniou, V. *et al.* , 2004, **Optical counterparts of the X-ray sources** (poster), "Galaxies viewed with *Chandra* , workshop" (Cambridge, MA)

3 Observing runs

• October 2004, Magellan (Baade) 6.5m telescope (IMACS imaging of *Chandra* SMC fields)
• November 2004, AAT 4m telescope (2dF spectroscopy of the optical counterparts of X-ray sources in the SMC)

4 Publications

1. Zezas, A., *et al.* , ApJ Suppl, submitted
2. Jenkins, L. P., Roberts, T. P., Ward, M. J., & Zezas, A. 2004, MNRAS, 352, 1335
3. Kaaret, P., Ward, M. J., & Zezas, A. 2004, MNRAS, 351, L83
4. Jenkins, L. P., Roberts, T. P., Ward, M. J., & Zezas, A. 2004, MNRAS, in press (astro-ph/0411274)
5. Baldi, A., Raymond, J. C., Fabbiano, G., Zezas, A., Rots, A. H., Schweizer, F., King, A. R., & Ponman, T. J. 2004, ApJ submitted, (astro-ph/0410192)